ON THE MORPHOLOGY OF THE NEPHRIDIUM OF NEREIS VEXILLOSA GRUBE

MEREDITH L. JONES

Dept. of Zoology, University of California, Berkeley, California

It has been well established that certain of the Nereidae are capable of surviving in waters of low salinity. In the field this is demonstrated by their invasion of brackish and even fresh waters (Johnson, 1903; Hartman, 1938; Smith, 1950, 1953, 1956), and has also been suggested in the experimental work of some investigators (Schlieper, 1929; Nomura, 1930; Jürgens, 1935; Sayles, 1935; Beadle, 1937; Ellis, 1937; Topping and Fuller, 1942; Krishnan, 1952; Smith, 1955). In spite of the fact that many physiological studies have been carried out on various nereids, only a few morphological descriptions of the presumed osmoregulatory organ of these annelids, the nephridium, are to be found in the literature.

The first detailed description of nephridial morphology was made by Goodrich (1893) on Nereis diversicolor. He found three sections along the length of the nephridial tubule, each grading into the next. The sections varied in respect to the presence or absence of cilia, the diameter of the tubule lumen, and the extent of convolution of the tubule.

Fage (1906) studied Perinereis cultrifera, confining his work to living material. He also found areas of ciliation, but these differed from those observed by Goodrich in N. diversicolor. Much later, in his extensive review of observations of nephridia and genital ducts, Goodrich (1945) re-stated his earlier findings but added little to them. In his work on Lycastis indica, Nereis chilcaensis, and Perinereis nurtia, Krishnan (1952) made a study of the nephridia of each species and compared them with respect to vascularization and size, relative to body size.

Because of the paucity of adequate morphological studies on nereid nephridia, it was felt that further study was in order, to provide a better basis for physiological work, and for later studies of comparative functional morphology.

MATERIALS AND METHODS

Specimens of Nereis vexillosa utilized in this study were obtained from a breakwater at the Berkeley Yacht Harbor, in San Francisco Bay, California. Although no salinity determinations were made at this time, the annual salinity range for this area is from 26.3 to 32.4% (approximately 73 to 90% sea water), according to Sumner et al. (1914) and Miller et al. (1928).

The worms were relaxed by gradual addition of 30% ethyl alcohol, fixed in Bouin’s fixative and serially sectioned at eight micra. They were then stained with

1 Representing a portion of a thesis submitted in partial satisfaction for the degree of Master of Arts in Zoology at the University of California at Berkeley.
2 Present address: United States Naval Mine Defense Laboratory, Panama City, Florida.
Harris' haematoxylin and counterstained with eosin Y. Other fixatives and stains were utilized, but these gave poor results.

In order to obtain a graphic representation of the canal as it passed through the nephridial mass, a plaster-of-Paris reconstruction was made. Camera lucida drawings were transferred to sheets of paraffin of proper thickness, and as the replica was built up, the lumen of the canal was hollowed out. Later, the canal was filled with plaster, and the surrounding paraffin was melted away.

**Nephridial Morphology**

The nephridia of *Nereis vexillosa* are paired organs in the coelomic cavity of each segment, just lateral to the ventral longitudinal muscle bundles, near the base of each parapodium. Within the broad base of attachment of the nephridium to the body wall, the nephridial canal opens to the exterior by way of the nephridiopore (Figs. 1, 2, 6, NPR). The internal opening of the nephridial canal, the nephrostome (Figs. 1, 3, 5, NST), is found at the end of an anterior extension of the canal (the post-septal canal, Figs. 1, 3, PSC) which leaves the mass of the nephridium and passes anteriorly, through the inter-segmental septum (Figs. 1, 3, 5, SEP), to the next segment.

Externally, the nephridium is a discrete mass of tissue, varying from globose or pyriform to irregular in shape. The surface may be ridged to some extent, because of the passage of the nephridial canal close to the surface. In mature worms of from 55 to 70 segments (ca. 70 mm. long when relaxed) nephridia were approximately 250 micra at their widest and about the same dorso-ventrally. They measured nearly 200 micra through their antero-posterior axis, exclusive of the post-septal canal and nephrostome which, in themselves, were about 300 micra in length.

In section, the convoluted nephridial canal is seen as many perforations in the...
nephridial tissue (Figs. 1, 2, 3, 4, NC). A fairly discrete wall often lines the tubule, although, usually, the boundaries of these cells are difficult to resolve (Fig. 4). The surface of the nephridium is covered by a single, very thin layer of squamous coelomic epithelium cells (Fig. 2, EPI). It is well to point out that, as far as is known, all nereid nephridia have this general configuration, i.e., a convoluted canal in the nephridial mass. An apparent contradiction to this fact occurs in a recent text (Prosser et al., 1950, pp. 17-18) where it is stated that “. . . the nephridium of *N. cultrifera* is a simple sac.” This is justified by a figure modified from Jürgens (1935) which had been redrawn from the work of Fage (1906). Fage’s original figure was a surface view of the nephridium of *Nereis cultrifera*, and in subsequent copyings, the delicate shadings which showed surface texture were lost, and the figure evolved to that of an optical section of the nephridium. The fate of the figure notwithstanding, Fage (1906, p. 338) described the nephridium as a “. . . masse spongieuse, perfoirée en tous sens par un grand nombre de canaux”; therefore, it is certainly not a simple sac. The matrix of the nephridium is a highly vacillated, syncitial, network of loose connective tissue, which serves to bind the convolutions of the nephridial canal.

Nuclei are of two types, a smaller kind, rich in chromatic material (3 × 5 μ), and a larger, clearer kind (5 × 10 μ). Nuclei of both types are usually found in or near the canal walls, and only occasionally are they seen isolated in the matrix tissue (Figs. 2, 3, 4).

No blood vessels have been noted within the nephridial mass, and in only two places is the nephridial system approached by vascular elements. One blood vessel passes over the anterior face of the nephridium (Fig. 3, BV) and another, the ventral segmental vessel, lies along the post-septal canal (Figs. 3, 5, VSV). In neither case is the association intimate, and there is little opportunity for the transfer of materials from one structure to the other. Although neither Goodrich (1893) nor Fage (1906) mentions the relationships between the nephridium and the vascular system, Krishnan (1952) has indicated that in *Lycastis indica*, *Nereis chilkaensis*, and *Perinereis nuttia*, blood vessels are found in close association with nephridia. He also points out that the extent of nephridial vascularization is inversely related to the salinity of the environment.

Occasionally, eosinophilic granules have been seen in the tubule walls and the matrix tissue (Fig. 4, EG). There is no special distribution along the length of the canal, and no special accumulations in the nephridial mass. Goodrich (1893) mentioned minute granules in the cells of the tubule wall in *N. diversicolor* and considered these to be composed of excretory materials. Fage (1906) observed that with the addition of neutral red to the sea water bathing the freshly-dissected nephridia of *Perinereis cultrifera*, granules were formed which were similar to those which were observed in untreated nephridia, and which Fage terms, excretory granules (grains d’excrétion).

The post-septal canal (Fig. 3, PSC) is produced anteriorly as an extension of the nephridial canal, and is covered by the same thin squamous layer which invests the nephridium. Nuclei are uniformly scattered along its length and are concentrated in a band at the level of the septum (Fig. 5, NB). Anterior to the septum, the post-septal canal enlarges and gives rise to the funnel-shaped nephrostome. The lateral margin of the nephrostome is slightly recurved, and around the entire rim, there are numerous cytoplasmic processes (Fig. 5, CP).
At the terminal end of the nephridial canal, the wall of the lumen thins and becomes continuous with the invaginated cuticle of the outer surface to form the nephridiopore (Fig. 6, NPR). In this respect, the structure of this area differs from that of *N. diversicolor* and *N. chilkaensis*, for Goodrich (1893) states that in *N. diversicolor* the wall of the tube pierces the epidermis, and Krishnan (1952) presents a figure showing the same condition in *N. chilkaensis*.

By means of camera lucida drawings, the entire course of the convolutions of the nephridial canal was followed from the nephrostome to the nephridiopore. It was then possible to ascertain the extent of ciliation within the lumen of the canal (Fig. 4, CIL). It was seen that the ciliation of the nephrostome is extremely heavy, and forms a tightly wound swirl in the throat of the nephrostome (Fig. 5, CM). The heavy ciliation is maintained throughout the rest of the post-septal canal, and gives a characteristic “star” or “wagon wheel” aspect to transverse sections of this structure. The ciliation of the portion of the canal included within the nephridial mass is constant, but not uniform. No obvious areas of heavy or sparse ciliation, such as were noted by Goodrich (1893) in *N. diversicolor*, have been observed here, and in general, the midportion is only slightly more heavily ciliated than either end. In the region of the nephridiopore (Fig. 6), the canal is devoid of cilia for about the last 40 micra of its length. It has also been noted that in *N. verilllora* the cilia are never attached on only one side of the lumen as Goodrich reported in *N. diversicolor*. In addition, no tufts of cilia, such as Fage (1906) has described in the nephridial canal of *Perinereis cultrifera*, have been seen here.

The plaster reconstruction (Fig. 7) shows that after the post-septal canal joins the nephridial mass, the canal is thrown into fairly tight, somewhat spiraled convolutions (I, Fig. 7). It then winds back and forth along the medial surface, roughly parallel to the antero-posterior axis (II, Fig. 7). Next, it passes to the mid-lateral portion of the mass and is once more tightly convoluted (III, Fig. 7). This condition gives way to a relatively straight length which terminates at the nephridiopore (Fig. 7, NPR).

In addition to affording a three-dimensional view of the path of the canal through

---

**Key to lettering:**
- BV, blood vessel; CIL, cilia; CM, mass of cilia; EG, eosinophilic granules; EPI, coelomic epithelium; NB, band of nuclei of nephrostome; NC, nephridial canal; NPR, nephridiopore; NST, nephrostome; CP, cytoplasmic processes of nephrostome; PSC, post-septal canal; SEP, intersegmental septum; VSV, ventral segmental blood vessel; I, II, III, first, second, and third regions of the nephridial canal, respectively.

**FIGURE 2.** General view of a nephridium, transverse section (8 μ, Harris’ haematoxylin and eosin; the cavity extending internally from the area of the nephridiopore, NPR, is a longitudinal fold of the body wall; the ventral nerve cord is to the left of the figure and the para-podium is to the lower right).

**FIGURE 3.** View of nephridium and its associated nephrostome, frontal section (8 μ, Harris’ haematoxylin and eosin).

**FIGURE 4.** Detailed view of nephridial tissue (8 μ, Harris’ haematoxylin and eosin).

**FIGURE 5.** Detailed view of the nephrostome of Figure 3.

**FIGURE 6.** Detailed view of the nephridiopore, transverse section (8 μ, Harris’ haematoxylin and eosin; the large cavity extending toward the upper left of the figure is a longitudinal fold of the body wall).

**FIGURE 7.** Plaster reconstruction of the nephridial canal, view of the anterior face. (The consecutive numbers indicate the course of the canal; section I, 1-18; section II, 19-30; section III, 31-55.)
the nephridium, the reconstruction shows three regions which merge gradually into one another. After the narrow post-septal canal joins the nephridium, the canal becomes slightly enlarged through the first region of convolution (I, Fig. 7). The canal is then further enlarged to its maximal diameter as it passes to the medial surface (II, Fig. 7). It becomes narrowed in the second series of tight convolutions (III, Fig. 7), and it is at its minimal diameter as it passes to the nephridiopore. This condition is reflected to some extent in Figure 8, which is a graph of the inner diameter along the length of the canal (a measurement of the outer diameter, which would show the thickness of the canal wall, was not possible, due to the poor definition of the cells of the wall). It is of interest to mention the regions of the tubule within the nephridium, as determined by Goodrich and Krishnan, although such differences may well be due to observations of different species. In N. diversicolor, Goodrich (1893) found a much convoluted portion with few cilia, into which the post-septal canal led. The next region was very narrow, and the cilia here were confined to one side of the canal. The last section was short, less convoluted, moderately wide, and without cilia. In N. chilkaensis, Krishnan (1952) found that the first portion of the canal, as it enters the nephridium, is convoluted and ciliated. The next portion is wider, without cilia, and longer than the preceding section.

**Figure 8.** Graphic representation of the inner diameter of that part of the nephridial canal within the nephridial mass (reconstructed by measuring the shortest diameter of elliptical sections of the nephridial canal).

This latter portion gives way to a canal which leaves the body of the nephridium and terminates at the nephridiopore.

The mean diameter of the nephridial canal upon which the reconstruction (Fig. 7) and the graph (Fig. 8) were based, was 24 μ, and the over-all length of the canal within the nephridial mass (not including the nephrostome or the post-septal canal) was approximately 1.7 mm.

The author wishes to acknowledge advice, criticisms, and suggestions from Dr. Ralph I. Smith and Dr. Kenneth B. DeOme of this Department, and from Dr. Willard D. Hartman, of the Peabody Museum, Yale University.

**Summary**

1. The morphology of the nephridia of *Nereis vexillosa* Grube is described.
2. Comparisons are made with the morphology of the nephridia of certain other nereids and differences are noted. Chief among these are, in *N. vexillosa*:
   a. that ciliation extends along the whole length of the nephridial canal, with the exception of a short region just preceding the nephridiopore;
b. that three general regions of the nephridial canal are noted, on the basis of the diameter and the amount of convolution;

c. that the wall of the nephridiopore appears to be inserted on the invaginated surface cuticle.

3. A reconstruction of the nephridial canal is presented in which the course of the canal is readily seen.

LITERATURE CITED


View This Item Online: https://www.biodiversitylibrary.org/item/17192
DOI: https://doi.org/10.2307/1539072
Permalink: https://www.biodiversitylibrary.org/partpdf/23195

Holding Institution
MBLWHOI Library

Sponsored by
MBLWHOI Library

Copyright & Reuse
Copyright Status: In copyright. Digitized with the permission of the rights holder.
License: http://creativecommons.org/licenses/by-nc-sa/3.0/
Rights: https://biodiversitylibrary.org/permissions

This document was created from content at the Biodiversity Heritage Library, the world’s largest open access digital library for biodiversity literature and archives. Visit BHL at https://www.biodiversitylibrary.org.